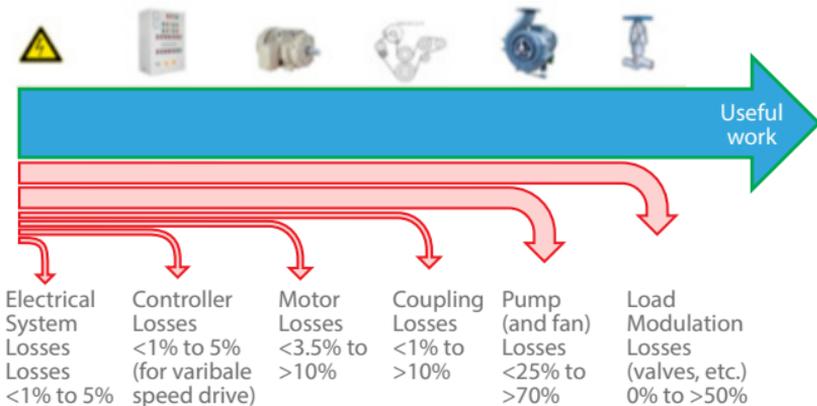


# Pump System *Cheat Sheet*

## Top 10 Energy Conservation Measures

1. Shut down pumps when not needed by manufacturing processes
2. Operate the minimum number of pumps that systems require
3. Use VFD instead of throttle valve for flow control
4. Trim or change pump impellers on oversized pumps
5. Reduce pipe and valve pressure loss
6. Re-optimize pumping system when system requirements change
7. Restore internal clearance
8. Replace worn throat bushings, wear rings, impellers, pump bowls
9. Install new properly sized/selected pump
10. Replace standard efficiency motor with NEMA premium motors

## Pump System Energy Losses



*\*Courtesy of Bhaskaran Gopalakrishnan*

## Pump Brake Horse Power Formula

$$\text{Pump Brake Horse Power (hp)} = \frac{\text{Flow Rate (GPM)} \times \text{Head (ft w.c.)} \times \text{SG}}{3960 \times \text{Pump efficiency}}$$

## Pump Affinity Laws

|  |  |   |
|--|--|---|
| $\frac{Q_2}{Q_1} = \frac{N_2}{N_1}$ <p>Q = Fan flow rate</p> | $\frac{H_2}{H_1} = \left(\frac{N_2}{N_1}\right)^2$ <p>N = Fan speed<br/>H = Fan head</p> | $\frac{P_2}{P_1} = \left(\frac{N_2}{N_1}\right)^3$ <p>P = Fan power</p> |
|--|--|---|

## Rules of Thumb

1. Annual motor operation cost: \$300/hp\*
2. Decreasing pump flow rate by 50% can reduce pump power by 88%

*\*Based on 5 cents/kWh, 93% efficiency, 3 shifts, 7 days a week operation, two weeks off/downtime.*

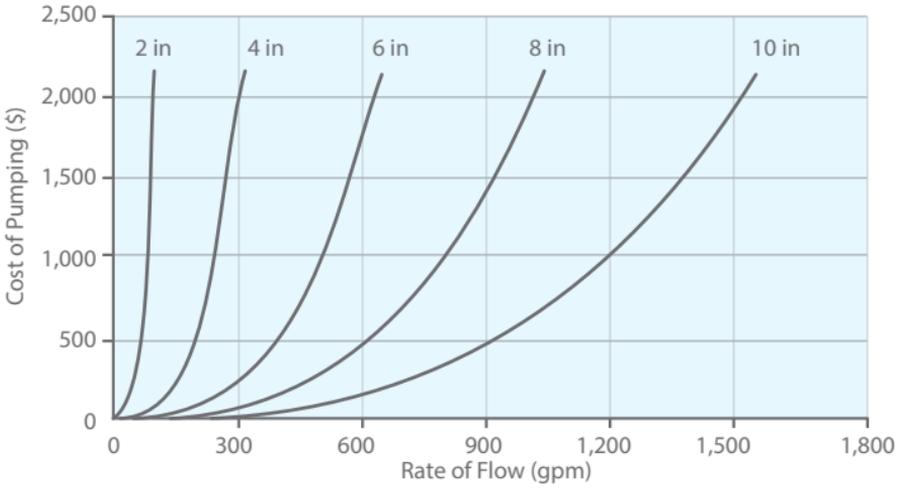
[betterbuildingsolutioncenter.energy.gov](http://betterbuildingsolutioncenter.energy.gov)

# Pump System *Cheat Sheet*

## Unit Conversion

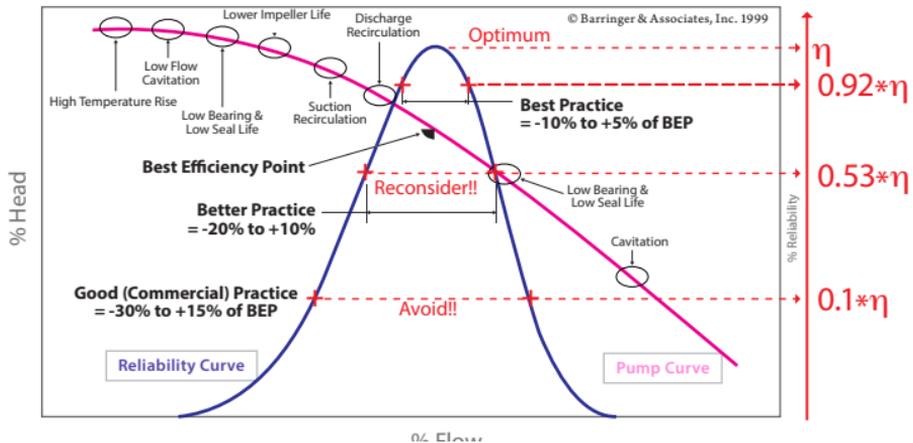
1 ft w.c. = 0.43 psi; 1 GPM = 0.00144 MGD; 1 hp = 0.746 kW

## Annual Water Pumping Cost for 1,000 Feet of Pipe



\*Based on 1,000 ft. for clean iron and steel pipes (schedule 40) for pumping 70°F water. Electricity rate of 0.05 \$/kWh and 8,760 operating hours annually. Combined pump and motor efficiency of 70%.

## Pump Curve Sensitivity for Pump Reliability



\*Courtesy of P. Barringer

## Energy Cost for Pump Driven by 100-hp Motor

| Operating Time | Energy Costs for Various Electricity Costs |            |            |            |             |
|----------------|--|------------|------------|------------|-------------|
|                | 2¢ per kWh                                 | 4¢ per kWh | 6¢ per kWh | 8¢ per kWh | 10¢ per kWh |
| 1 hour         | \$1.60                                     | \$3.30     | \$4.90     | \$6.60     | \$8.20      |
| 24 hours       | \$39                                       | \$79       | \$119      | \$159      | \$198       |
| 1 month        | \$1,208                                    | \$2,416    | \$3,625    | \$4,833    | \$6,042     |
| 1 year         | \$14,500                                   | \$29,000   | \$43,600   | \$58,000   | \$72,600    |

## Resources

1. Integrated Energy Tool Suite by US Department of Energy
2. Improving Pumping System Performance: A Sourcebook for Industry US Department of Energy
3. Pump Tip Sheets by US Department of Energy